TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Alternative Aviation Fuels and the Army

48th AIAA Aerospace Sciences Meeting
January 4, 2010

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
04 JAN 2010	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Alternative Aviation Fuels and the Army	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Sattler, Eric	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA	**20462RC**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	TACOM/TARDEC
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)
	20462RC

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

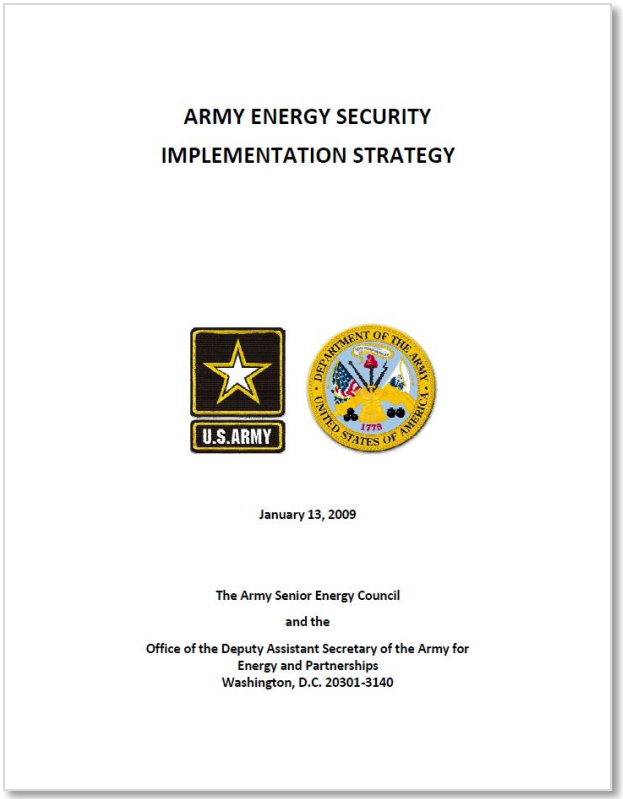
13. SUPPLEMENTARY NOTES
Presented at the 48th AIAA Aerospace Sciences Meeting January 4, 2010, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**17**	

Army Energy Security Core Characteristics


ARMY ENERGY SECURITY
IMPLEMENTATION STRATEGY

U.S.ARMY

January 13, 2009

The Army Senior Energy Council
and the
Office of the Deputy Assistant Secretary of the Army for
Energy and Partnerships
Washington, D.C. 20301-3140

Core Characteristics defining the ***Energy Security*** necessary for the full range of Army missions:

Surety: Preventing loss of access to power and fuel sources.

Survivability: Ensuring resilience in energy systems.

Supply: Accessing alternative and renewable energy sources available on installations.

Sufficiency: Providing adequate power for critical missions.

Sustainability: Promoting support for the Army's mission, its community, and the environment.

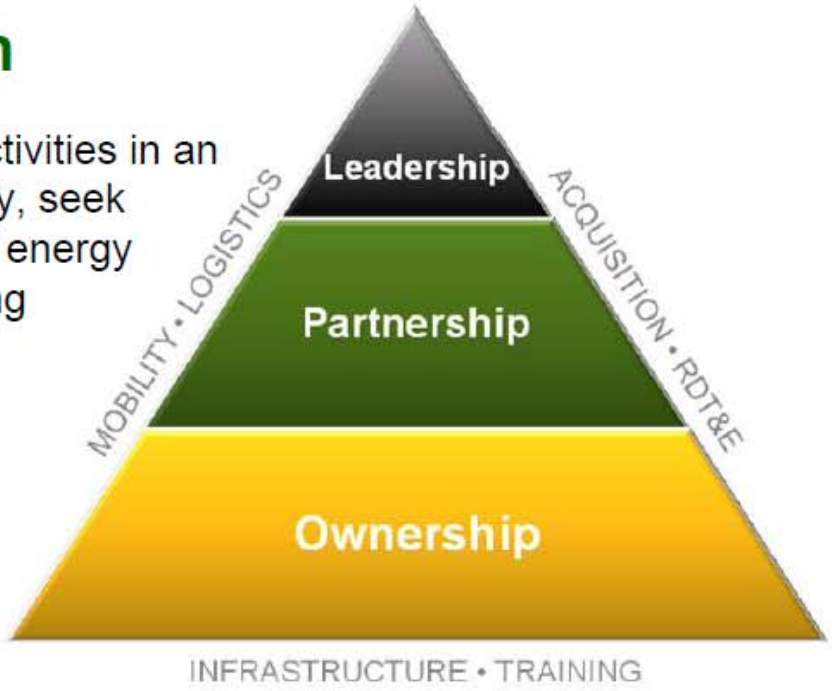
Army Energy Security Vision and Mission

Army Energy Security Vision

An effective and innovative Army energy posture, which enhances and ensures mission success and quality of life for our Soldiers, their Families, and Civilians through Leadership, Partnership, and Ownership, and also serves as a model for the nation.

Army Energy Security Mission

Make energy a consideration in all Army activities in an effort to reduce demand, increase efficiency, seek alternative sources, and create a culture of energy accountability, while sustaining or enhancing operational capabilities.



Army Energy Security Goals

Strategic Energy Security Goals (ESGs)

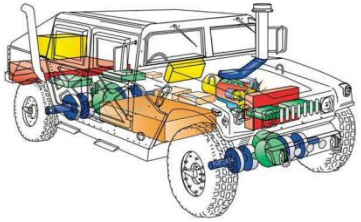
ESG 1: Reduced energy consumption.

ESG 2: Ensuring resilience in energy systems.

ESG 3: Increased use of renewable/alternative energy.

ESG 4: Assured access to sufficient energy supplies.

ESG 5: Reduced adverse impacts on the environment.



Tank Automotive Research, Development and Engineering Center (TARDEC)

TARDEC is the Ground Systems Integrator for the DOD

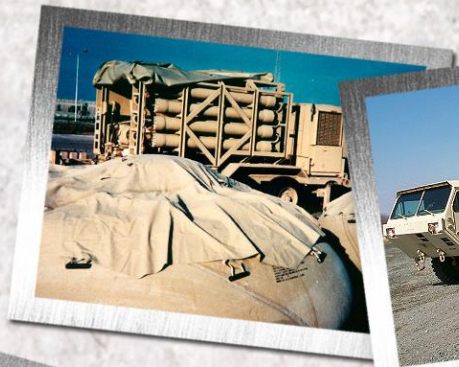
Responsible for Research, Development and Engineering Support to 2,800 Army systems and many of the Army's and DOD's Top Joint Warfighter Development Programs

Portfolio

PORTFOLIO

Combat Vehicles

- Heavy Brigade Combat Teams
- Strykers
- MRAPs
- Ground Combat Vehicles (Future)



Force Projection

- Fuel & Water Distribution
- Force Sustainment
- Construction Equipment
- Bridging
- Assured Mobility Systems

Tactical Vehicles

- HMMWVs
- Trailers
- Heavy, Medium and Light Tactical Vehicles

Robotics

- Technology Components
- Demonstrators
- Military Relevant Test & Experimentation
- Transition and Requirements Development

Technology Thrust Areas

Ground Vehicle Power & Mobility

- Prime Power (Powertrain)
- Non Primary Power
- Power & Thermal Management
- Energy Storage
- Track & Suspension
- Alternative Energy

Ground Systems Survivability

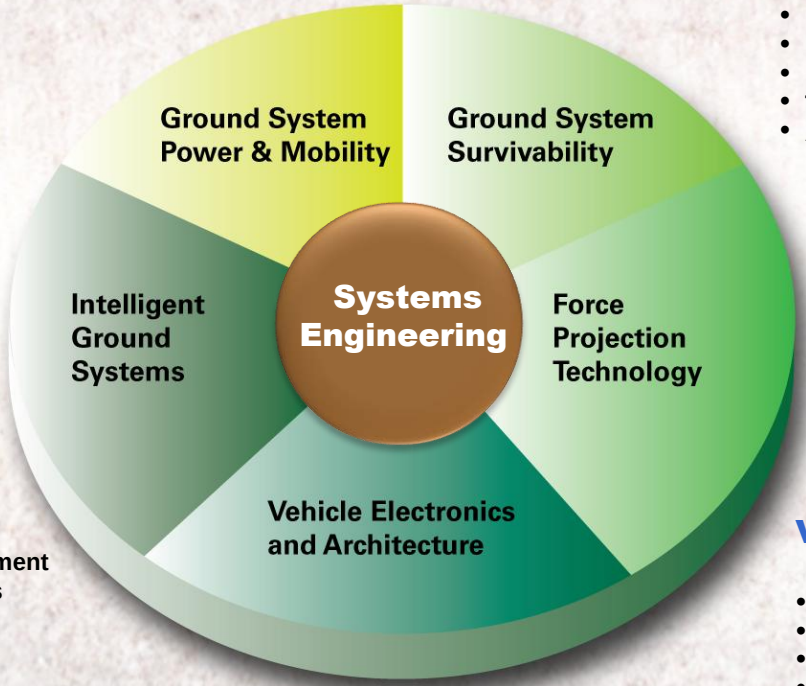
- Integrated Vehicle Protection Systems
- Active Defense
- Signature Management
- Laser Vision Protection
- Ballistic Protection
- Crew Survivability

Force Projection Technology

- Water Generation, Purification, Storage, Distribution & Quality Surveillance (QS)
- Petroleum Storage, Distribution & QS
- Material Handling Equipment
- Petroleum, Oils & Lubricants Technology
- Mechanical Countermine Equipment
- Tactical Bridging
- Alternative Fuels

Intelligent Ground Systems

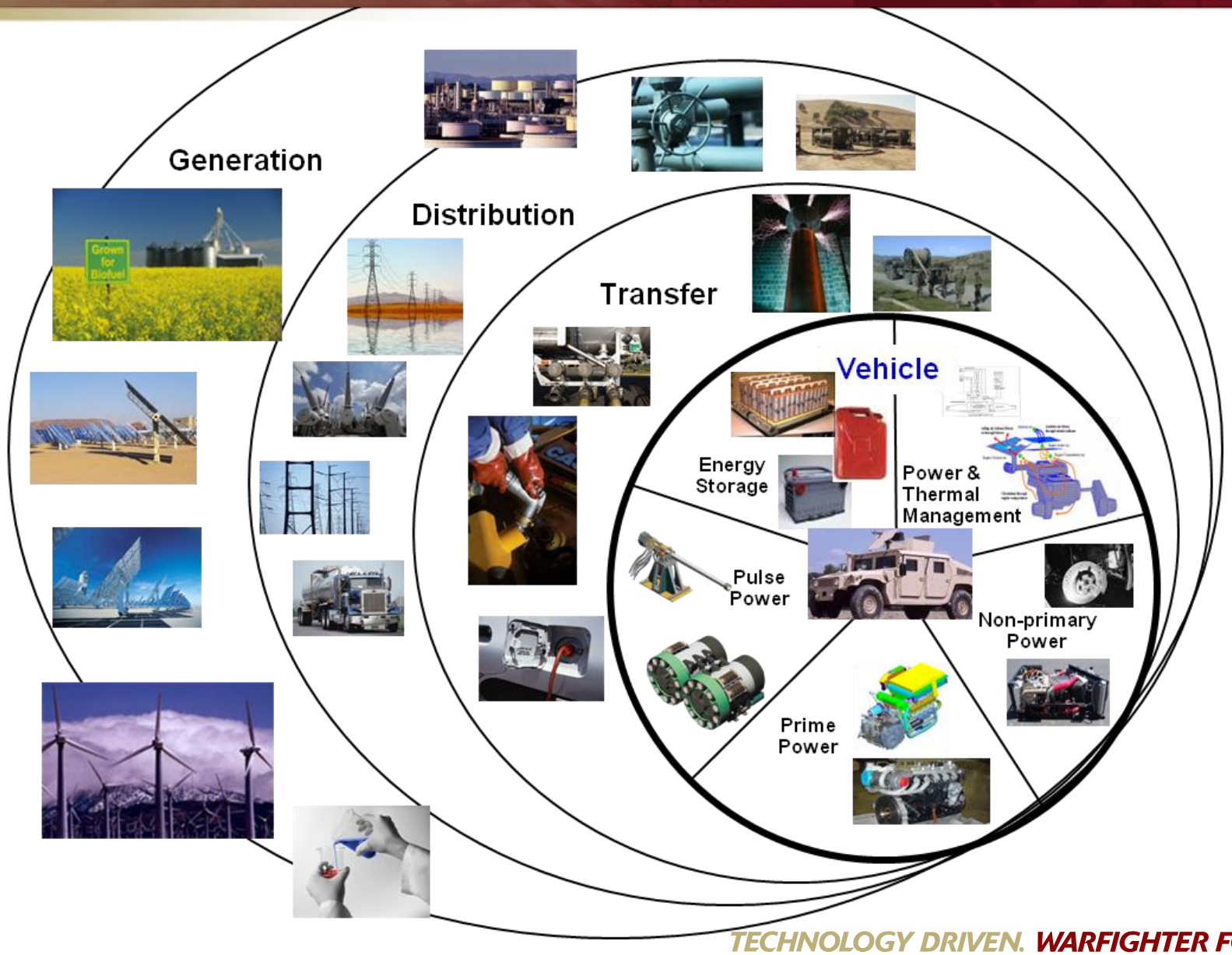
- Autonomous Robotics Systems
- Safe Operations Technologies
- Indirect Vision Technologies
- Unmanned Systems Technology Development
- 360° Situational Awareness Technologies
- Soldier Machine Interfaces
- Connected Vehicles



Vehicle Electronics & Architecture

- Electronics Integration
- Data Architecture
- Condition-Based Maintenance (CBM+)
- Power Architecture/Management

TARDEC's End-to-End Energy Business: From Generation to Application



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Army Energy Consumption

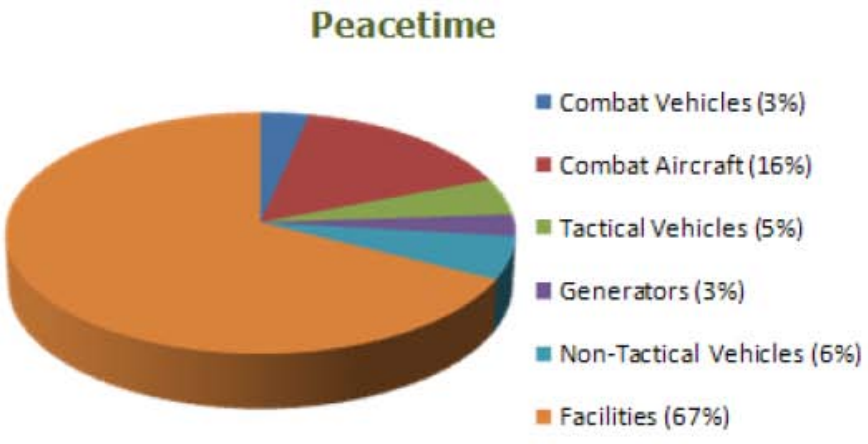
FY 2007 – 2008 Energy Consumption

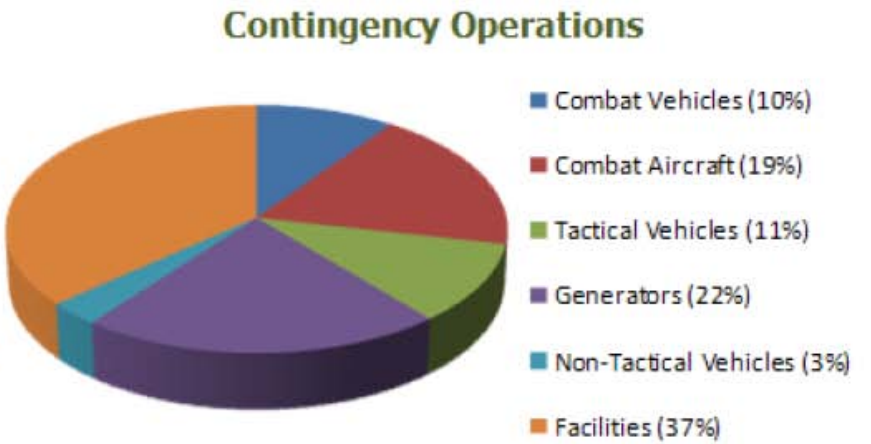
Consumption & DESC Purchases

8% Increase from 176 to 190 Trillion Btu

Energy Cost

40% Increase from 2.9 to 4.1 Billion Dollars



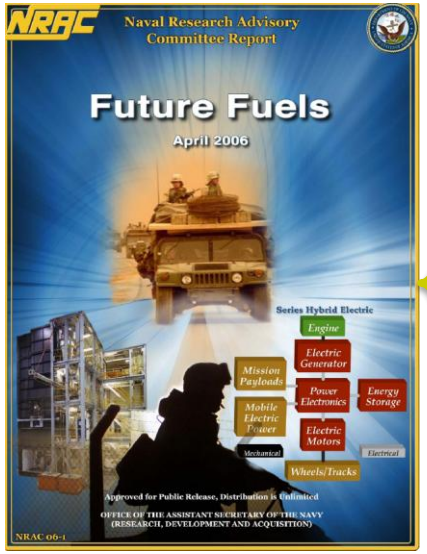


Sources: Defense Science Board. More Fight – Less Fuel (February 2008); Department of the Army FY07 Annual Energy Management Report (December 2007)

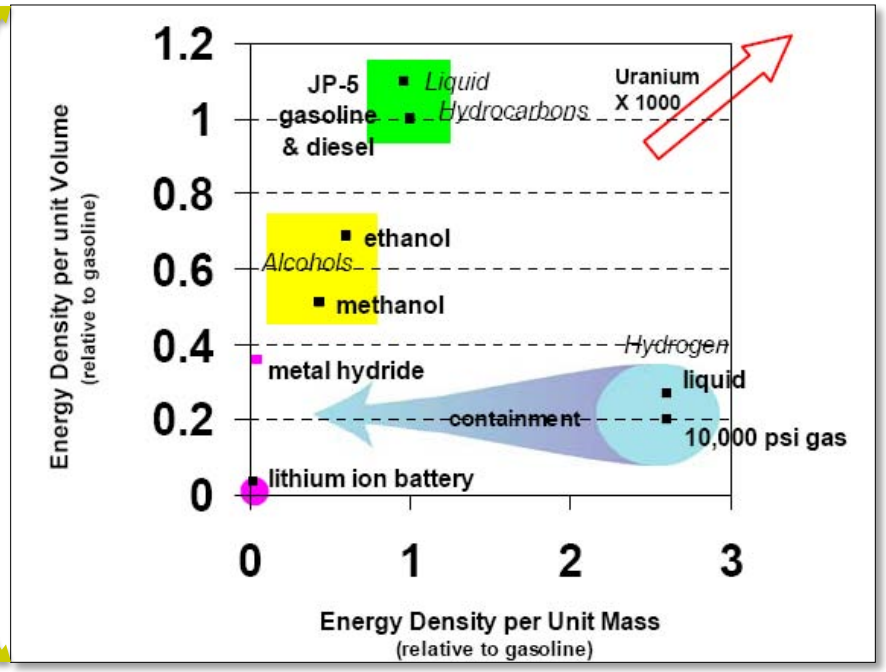
U.S.ARMY

Tactical Mobility Fuel
Energy Dense Liquid Hydrocarbons

LIQUID HYDROCARBONS – IDEAL FUEL FOR TACTICAL MOBILITY



Naval Research Advisory Committee Panel Report (April 2006)



DOD SINGLE FUEL POLICY

AVIATION KEROSENE GRADE (JP-8)
MIL-DTL-83133

JP-8 (Jet A-1 plus additives) is the primary fuel used for both air and ground equipment in all theaters, overseas and Continental U.S.

Why???

- ***Tactical Vehicle Designs*** impose severe limitations on volume and weight…
- ***…***therefore, ***Energy Density*** is the primary consideration for fuel
- ***…****and* ***Hydrogen is presently unsuitable*** as a tactical mobility fuel
  - energy intensive production
  - containment reduces energy density by 10-20X

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Alternative Source Liquid Hydrocarbons for DoD Ground Systems (Tactical/Combat)

Biomass Feedstock (renewables)

Fossil Energy Feedstock (large U.S. resource)

Petroleum Crude Oil
(declining discovery and production)

- Various conversion processes dependent on feedstock
- Product meeting military or commercial fuel specifications

Jet Fuels / JP-8

- Blending Stock (FT SPK, HRJ)
- "Drop in"
- **Single Fuel in the Battlefield***

*Diesel fuel in ground equip. allowed when supplying jet fuel not practicable or cost effective

Diesel Fuel / Commercial

- Blending Stock (B100)
- "Drop-in" (HRD?, FTD?)
- **Fuel most Army ground engines designed to operate on**

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Wide Variety of Engines in Army Equipment

Equipment Types

Construction Equipment

Material Handling Equipment

Combat Vehicles

Petroleum & Water Systems

Tactical Bridging

Tactical Generator Sets

Tactical Vehicles

Watercraft Systems

Aircraft / Helicopters

Red: Two-stroke diesel
Black: Four-stroke diesel
Blue: Gas Turbine

FVPDS (January 2000)
Fielded Vehicle Performance Data Systems
- >300,000 tactical/combat vehicles (150 - 1500 BHP)
- >240,000 trucks, class 2 to 8+ (150 – 500 BHP)
- >40,000 2-stroke powered vehicles (200 – 500 BHP)

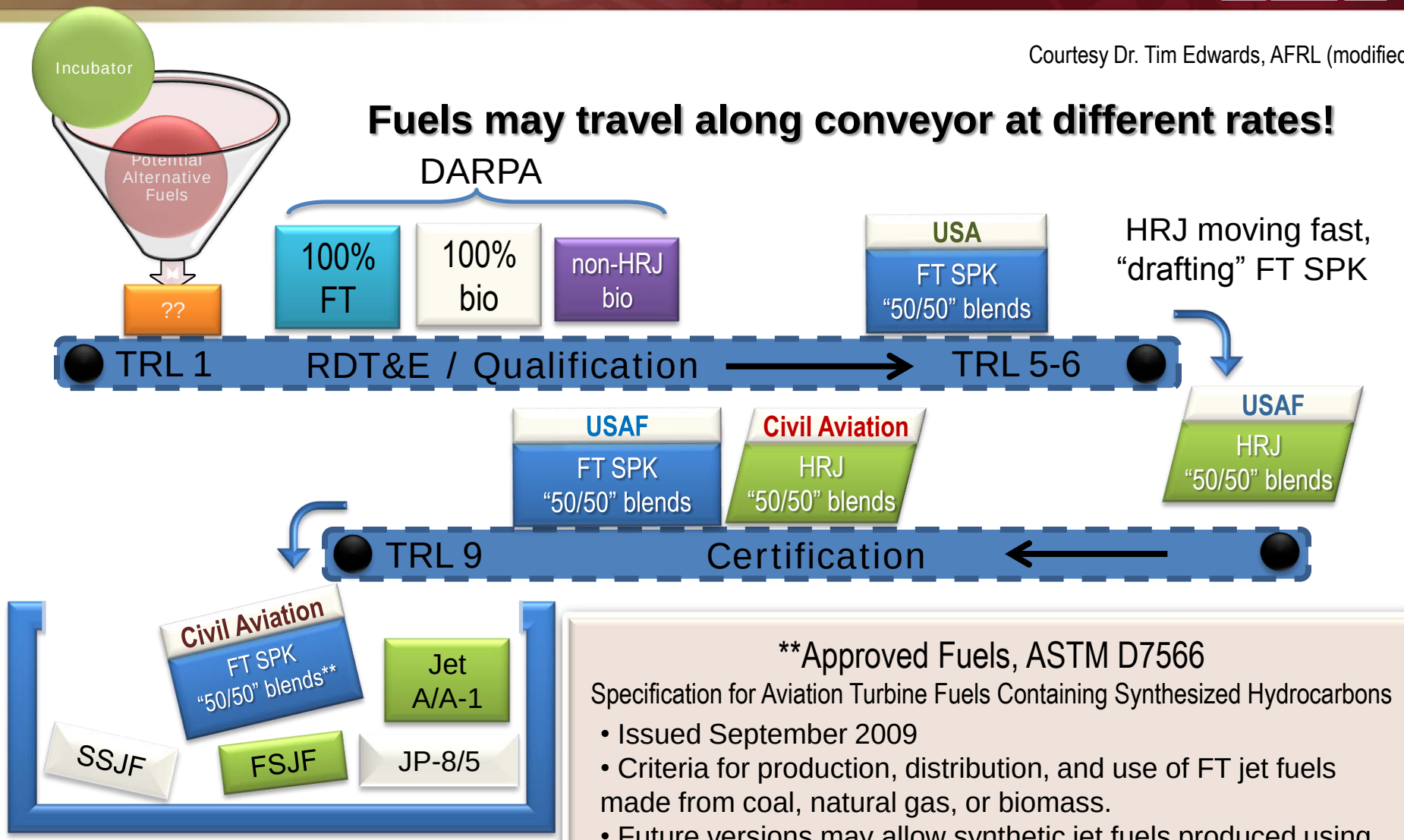
Vehicle (Engines) – Sampling

M1 Abrams (AGT-1500)
M109/M110 Self Propelled Howitzer (8V71T)
M2/M3 Bradley (VTA-903)
M88 Medium Recovery Vehicle (TCM-1790)
M578 LRC Light Armored Recovery Vehicle (8V71T)
M60 Family (TCM-1790)
Chaparral Missile Launcher (6V53T)
FAASV Fast Assault Ammunition Supply Vehicle (8V71T)
M551 Sheridan Assault Vehicle (6V53T)
Stryker (3126/C7)

HET Heavy Equipment Transporter (8V92TA)
HEMTT Heavy Expanded Mobility Tactical Truck (8V92TA)
PLS Palletized Loading System (8V92TA)
2.5 Ton Truck (LD-465/LDT-465)
M939 5 Ton Truck (NHC 250/6CTA8.3)
M915/M916 Line Hauler (NTC-400/S-60)
M917, M918, M919 Tractor (NTC-400)
HMMWV (GM 6.2/6.5 IDI)
CUCV Commercial Utility Cargo Vehicle (GM 6.2/6.5 IDI)
FMTV (C7)

Certification / Qualification Pipeline

Courtesy Dr. Tim Edwards, AFRL (modified)



**Approved Fuels, ASTM D7566

Specification for Aviation Turbine Fuels Containing Synthesized Hydrocarbons

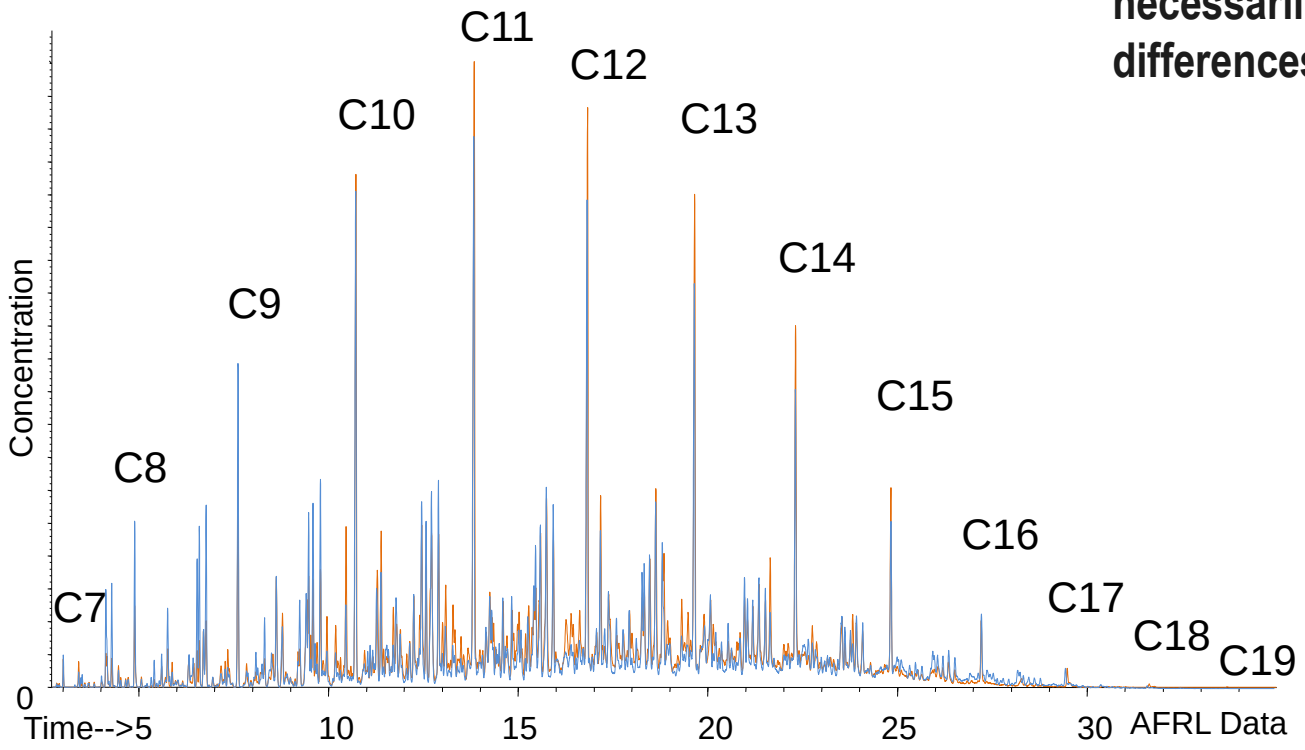
- Issued September 2009
- Criteria for production, distribution, and use of FT jet fuels made from coal, natural gas, or biomass.
- Future versions may allow synthetic jet fuels produced using other processes once they are qualified.

Fischer-Tropsch Synthetic Paraffinic Kerosene (FT SPK)
Hydroprocessed Renewable Jet (HRJ)
Semi-Synthetic Jet Fuel (SSJF)
Fully Synthetic Jet Fuel (FSJF)

Properties of Synthetic Paraffinic Kerosene (SPK)

JP-8

Fischer-Tropsch (FT) SPK*



*Synthetic Paraffinic Kerosene:
Hydrocarbons distributed across the full jet fuel boiling range and having on whole properties suitable for use as an aviation fuel.

- Nothing in FT SPK that is not in JP-8
- Not all compounds in JP-8 are necessarily in FT SPK, results in some differences in fuel characteristics

Low or no aromatics:
Lower fuel density and volumetric energy density, typ. higher cetane no., less solvency

Low or no sulfur:
No exhaust SOx

Low or no trace compounds:
Less inherent fuel lubricity

- Can impact component or engine performance and durability

RDT&E of Alternative Ground Fuels

EMERGING ALTERNATIVE FUELS MARKET

- DOD
- DOE
- Industry
- Academia
- Fuel Producers
- Equipment OEMs
- Other Government Agencies
- Standards Development Organizations

Market Connection

- Manufacturing technology
- Fuel data, samples
- Market drivers

Poor lubricity fuel may cause increased wear rates in fuel injectors and injection pumps.

Fuel / Component Evaluations

- Chemical composition
- Physical properties
- Component performance / durability

Engine Evaluations

- Fuel ignitability
- Fuel combustion
- Performance / durability

System Evaluations

- Operability
- Performance
- Demonstrations

Fuel Qualification

Fuel with low cetane ratings may cause cold-starting problems, and misfire and combustion instability, esp. for lt-med load operation.

Low fuel viscosity may result in fuel pump internal leakage and associated loss of power.

Approval and acceptability of alternative fuels for use in DOD ground equipment.

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Alternative Fuels Qualification

Blends of FT SPK and JP-8 undergoing qualification; based on similarity of HRJ with FT SPK, blends of HRJ and JP-8 will be integrated to conduct a concurrent qualification.

← Develop data needed to assess fuel's suitability for use. → ← Build user knowledge of and confidence in use of fuel. →

Laboratory Evaluations → **Component Evaluations** → **System Evaluations** → **Demonstrations**

- **Completed**
  - Fuel chemical composition and properties
  - Materials compatibility evaluations
  - Fuel blends studies
  - Limited component/engine/system testing (ground equipment)
  - Test track evaluation (HMMWV)
  - Tactical Wheeled Vehicle pilot field demo
- **In Progress**
  - Some engine testing (NATO test cycle)
  - Fuel injection test rig testing (rotary pump, high pressure common rail)
  - Cetane - Volatility window studies
- **Planning**
  - Tactical generator sets testing
  - Additional component/engine/system testing and demos (including Army Aviation)

Timelines for evaluations and demos dependant on the availability of test fuel volumes required.

Tactical Wheeled Vehicle (TWV) Pilot Field Demo

- **Demo not intended to assess long-term performance or durability of components, engines, or TWV when operating on synthetic fuel blends.**

This demo served to introduce synthetic fuel blends to the end user and to build acceptance of their use.

- **Field demo fleet operating at Ft. Bliss, TX (Aug 08 – Jul 09)**
  - M998 - HMMWV Truck Utility
  - M915A4 - Line Haul Truck
  - M925A2 - 5 Ton Truck Cargo
  - M1075 - 2.5 Ton LMTV Cargo
  - M1083A1 - 5 Ton MTV Cargo
  - M1089A1 - FMTV Wrecker
  - M978/M984 - HEMTT Tanker/Wrecker

TARDEC photo by R. Alvarez,
TARDEC Fuels & Lubricants Research Facility

- **Over 86,000 cumulative miles total**
  - Test vehicles – 47,000 miles and 9,500 gallons of synthetic fuel blend
  - Control vehicles – 39,000 miles and 6,900 gallons of JP-8
  - Individual vehicles – A couple of vehicles operated nearly 5100 miles, many a few hundred miles
- **No issues with vehicle operation throughout demo, no discernible differences to drivers and mechanics between operation of test vehicles versus control vehicles**